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NUMERICAL SIMULATION OF THE NIOBEC MINE: STABILITY OF THE PRODUCTION SHAFT

LUC CLOSSET AND GUYLAINE HAMEL

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23 pp

MICROMEDIA

NUMERICAL SIMULATION OF THE NIOBEC MINE STABILITY OF THE PRODUCTION SHAFT

by

Luc Closset* et Guylaine Hamel*

ABSTRACT

The Mining Research Laboratories of the Canada Centre for Minerals and Energy Technology (CANMET) have collaborated for several years on aspects of mining technology, with Niobec Mine, located in Saint-Honoré, Québec.

Recently, the technical staff at the mine contacted the Mining Research Laboratories to request a study on the recovery of a series of pillars located close to the main production shaft, which is an essential mine access.

The most useful tool, for this large scale study, was found to be three dimensionnal numerical simulation using BEAP3D, a software which is based on boundary element theory.

Four numerical simulations have been run, using the various mining options and available data; each simulation included four mining steps. Results have shown that the mining of the pillars should not have destabilizing effects on the shaft area, however, this operation will create large stope walls perpendicular to the major principal stress orientation, and large induced tension stresses parallel to the wall. A set of conditions which could cause rock falls. It is firmly recommended that this issue should be adressed in a separate study using accurate stope geometry for further precision.

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* Physical Scientists - Canadian Mining Technology laboratory - Mining Research Laboratories - CANMET - Energy, Mines and Resources Canada, Ottawa

Key words : numerical simulation, BEAP3D, boundary element, shaft, pillars

SIMULATION NUMÉRIQUE DE LA MINE NIOBEC
STABILITÉ DU PUITS D'EXTRACTION

par

Luc Closset* et Guylaine Hamel*

RÉSUMÉ

Les Laboratoires de recherche minière du Centre canadien de la technologie des minéraux et de l'énergie (CANMET) collaborent depuis plusieurs années avec la mine Niobec située à St-Honoré au Québec.

Dernièrement, le personnel technique de la mine Niobec a contacté les laboratoires de recheche minière pour proposer l'étude de la stabilité de la zone du puits d'extraction advenant l'exploitation d'une série de piliers situés à proximité de cet accès essentiel pour la continuation des opérations.

Pour étudier quantitativement l'influence des travaux, la simulation numérique en trois dimensions, par le biais du programme BEAP3D, utilisant la méthode des éléments frontières, a été retenue.

Quatre différentes simulations, incluant chacune quatre étapes d'exploitation, ont été éffectuées en se basant sur les données. Les résultats ont montré que l'exploitation projetée des piliers ne devrait pas avoir un effet négatif sur la stabilité du puits d'extraction. Cependant la création de murs de chantiers de grandes dimensions, perpendiculaires à la direction de la plus grande contrainte principale, devrait induire d'importantes contraintes de tension. Des éboulements rocheux pourraient en découler. Il est donc recommandé aux exploitants de tenir compte de ce fait ou de l'étudier plus précisément.

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Mots clés : Simulation numérique, BEAP3D, éléments frontières, puits, pillier.

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INTRODUCTION

The Mining Research Laboratories of the Canada Centre for Mineral and Energy Technology (CANMET) have co-operated since 1986 with the operators of the Niobec Mine at St-Honoré in Quebec (Bétournay et al; Arjang; Labrie; Labrie et al) in the development of effective methods for designing excavations and predicting their stability. The study described in this report is a continuation of this co-operation in that it evaluates the effect of recovering a group of stope pillars on the nearby production shaft zone.

The geology of the rock mass and the mining method used have already been described in reports and publications. We therefore refer the reader to these for a complete description of these subjects (Bétournay et al; Gendron et al).

For the sake of clarity, however, we should mention that the mine works subvertical veins rich in niobium, in a carbonatite mass overlain by a hundred metres or so of a sedimentary rock known as the Trenton limestone. The stopes, which vary in horizontal extent, are subvertical and about 100 m (300 ft) high. Two levels are currently being worked, separated by a horizontal pillar about 30 m (100 ft) thick.

The study uses numerical simulation to predict, in an appropriate and economical exercise the variation in stresses in the shaft zone. The use of a three-dimensional model is necessary because of the complexity of the geometry. For reasons of economy, time and resources, our choice fell to the boundary element method, which facilitates solution of the differential equations of the laws of elasticity with only one integration over the surfaces bounding the model, that is, just the walls of the excavations. This method allows us to avoid volume integration, which requires total discretization of the model and would be far more costly in terms of data preparation and computing time. Readers wishing to familiarize themselves with the technique of simulation can readily find very complete descriptions of the method elsewhere (Lachat and Watson; Starfield and Crouch; Diering; Yu et al; and so on).

This report is divided into five main parts which reflect the steps involved in carrying out this type of study:

(1) Data review and selection
(2) Simulations
(3) Results
(4) Conclusions
(5) Recommendations.

DATA REVIEW AND SELECTION

The numerical simulation of a mine structure depends on the following data, which must be determined, measured, calculated or estimated to create a reliable numerical model, or which at least falls within acceptable limits of accuracy:

(a) the forces applied against the model or, in the case of a mine structure, the initial stresses present in the rock mass;

(b) the law of behaviour of the rock mass and the parameters associated with it; and

(c) the geometry of the excavations and the sequence in which they are created.

INITIAL STRESSES IN THE ROCK MASS

The initial stresses in the rock mass were measured in 1987 by Arjang and show the presence of large horizontal tectonic stresses. The number of valid measurements and measurement sites used in the report is quite low. Because of their broad variability and relative spatial concentration, the establishment of a law of variation with depth is complex. The designers of the BEAP software assumed that initial stresses varied linearly with depth. We can write:

$$\sigma_{ij} = A_{ij} + B_{ij}\, z$$

where the variable z represents depth.

To check the stability of the shaft zone, two different models of variation in initial stresses as a function of depth were considered. The first type of loading, which had been used before for the two-dimensional numerical simulation of the Niobec Mine (see Labrie and Closset, 1989) can then be defined by parameters A_{ij} and B_{ij} below:

$$A_{ij} = B_{ij} = 0 \text{ if } i \neq j$$
$$A_{xx} = 16.35$$
$$A_{yy} = 3.35$$
$$A_{zz} = 0$$
$$B_{xx} = B_{yy} = 0.0145$$
$$B_{zz} = 0.027$$

with stresses being expressed in MPa and depth in metres.

This loading shows a large east-west initial stress which varies little with depth, and a much smaller north-south stress which varies with depth in the same way as the other horizontal stress. The vertical stress is caused solely by the weight of the incumbent ground.

The second type of loading may be considered more conventional , since it assumes that all initial stresses at the surface are zero:

$$A_{ij} = 0$$
$$B_{ij} = 0 \text{ if } i \neq j$$
$$B_{xx} = 0.0845$$
$$B_{yy} = B_{zz} = 0.027$$

In this case as well, the vertical stress is due only to the weight of the ground. It should be noted that, for this kind of initial loading, the ratio of the principal stresses remains constant with depth (3:1:1).

LAW OF BEHAVIOUR OF THE ROCK MASS

The BEAP software can only facilitate the simulation of linear, isotropic elastic rock masses. This behaviour is perfectly applicable macroscopically to the rock mass of the Niobec Mine, which has little fracturing and is near the surface and thus is subject to stresses which are low compared to the strength of the rock matrix. There is no evidemce to suggest that there is a major fault present in the mine.

In addition, the rock mass is homogeneous; therefore, the magnitude of the stresses in it should be independent of the elastic moduli introduced as data in the simulations.

GEOMETRY OF THE EXCAVATIONS

The geometry of the excavations was taken from the plans and cross-sections prepared by the mine during the summer of 1990. It was quickly apparent from the first examination of this data that, while the stope zone nearest the production shaft was described by plans and cross-sections, the adjoining stopes were defined summarily and incompletely on a number of views and plans. Moreover, after a more detailed review of the stopes in the central zone, numerous inaccuracies and inconsistencies found to exist between the different projections made the creation of an accurate model virtually impossible.

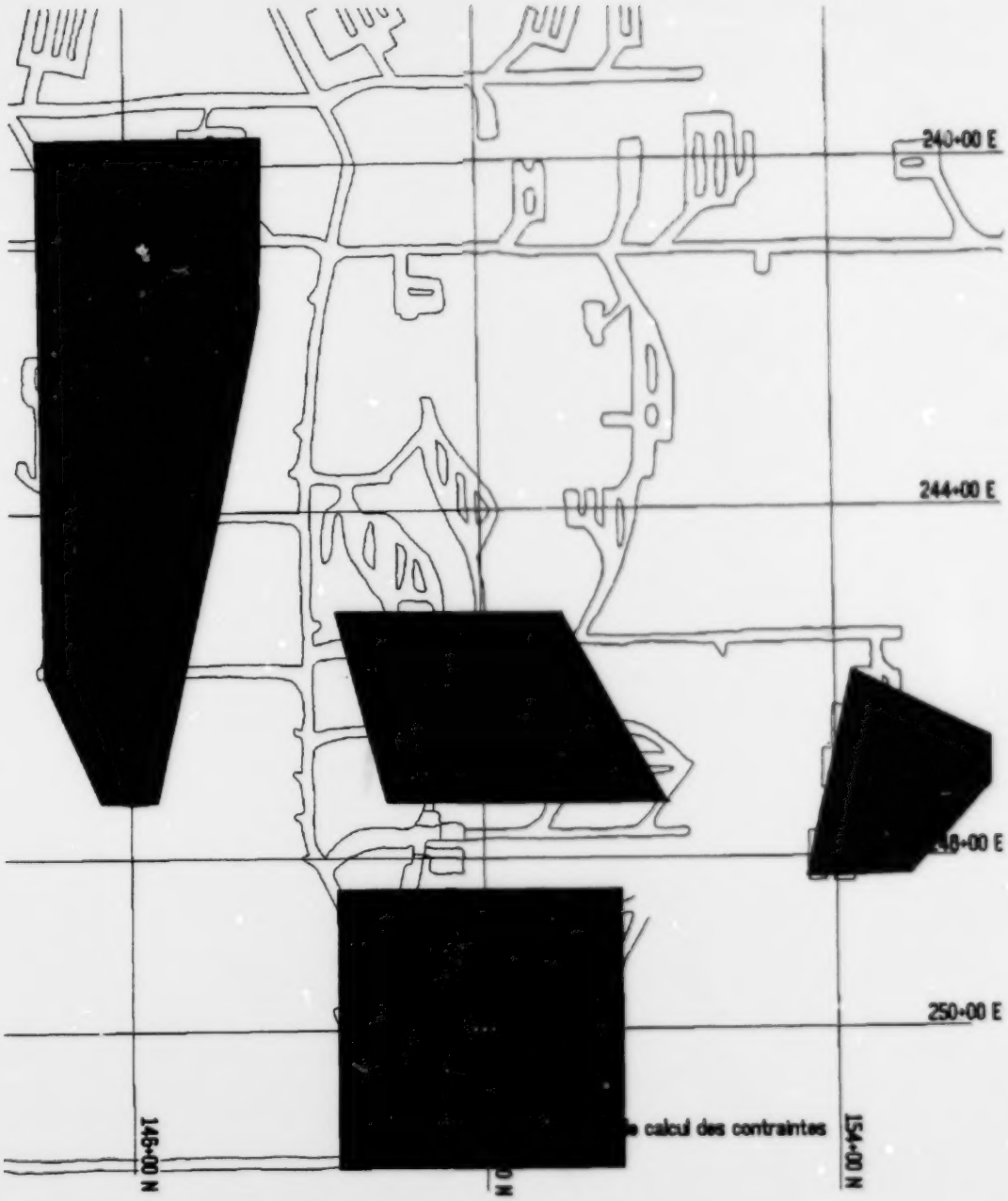


Figure 1. Level 300 and lateral extent of the groups of stopes

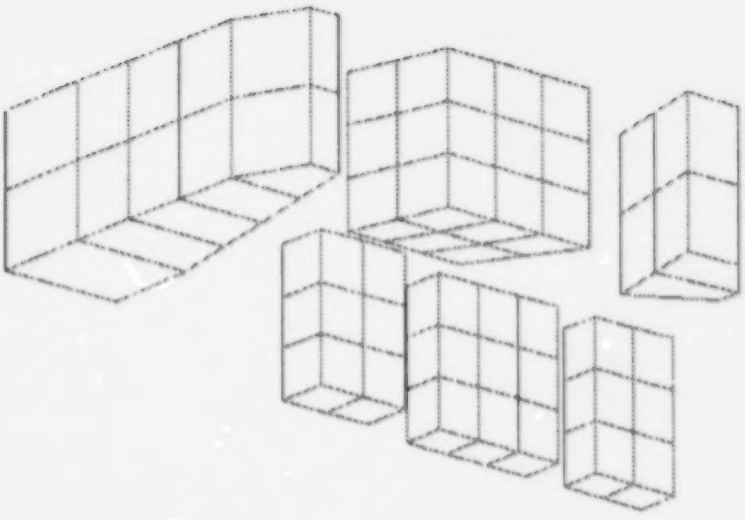


Figure 2. Geometry without surface

Additionally, restrictions of budget, time and materials (availability of computer equipment, available disk space and so on) affected the project. It was therefore necessary to simplify the geometries to allow relatively rapid simulations. Accordingly, two different geometries were created. The first was based on the plan views. The maximum horizontal extent of the stopes was estimated (see Figure 1), and we assumed a continuous vertical extent between the -300 and -600 elevations for the first level and the -700 and -1000 elevations for the second level. This first geometry joined a surface at elevation 0. Because of paucity of details in 3-D projections, small pillars were assumed to have been mined. This procedure thus exaggerates, to a significant degree, the real effects of mining on the shaft zone and therefore the results should be considered an upper limit.

In neither of the two cases was the excavation of the actual shaft explicitly simulated, since the purpose of the simulations described in this report was to check the changes in stress around the shaft resulting from mining the surrounding stopes pillars, and not to examine the modifications in stresses caused by the presence of the shaft itself. The results obtained will therefore provide a general trend rather than absolute answers.

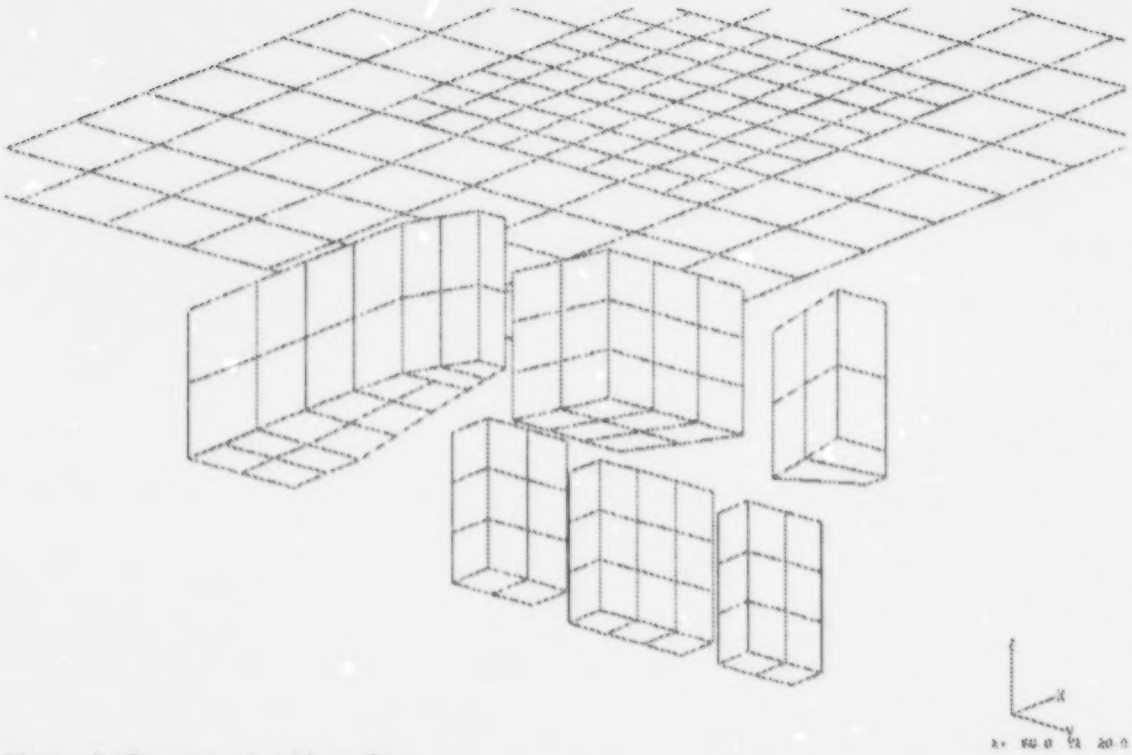


Figure 3. Geometry 1 with surface.

Considering the low level of precision of the geometry, we disregarded the presence of the Trenton limestone in both cases, or rather we assumed it had the same elastic properties as the carbonatite which it overlies.

As the BEAP3D software allows the simulation of stages of excavation, we created four stages to show the influence of the excavations around the periphery. Table 1 shows the different mining stages.

The second geometry is similar to the first, except for the stopes in the central zone, which are more precisely defined geometrically.

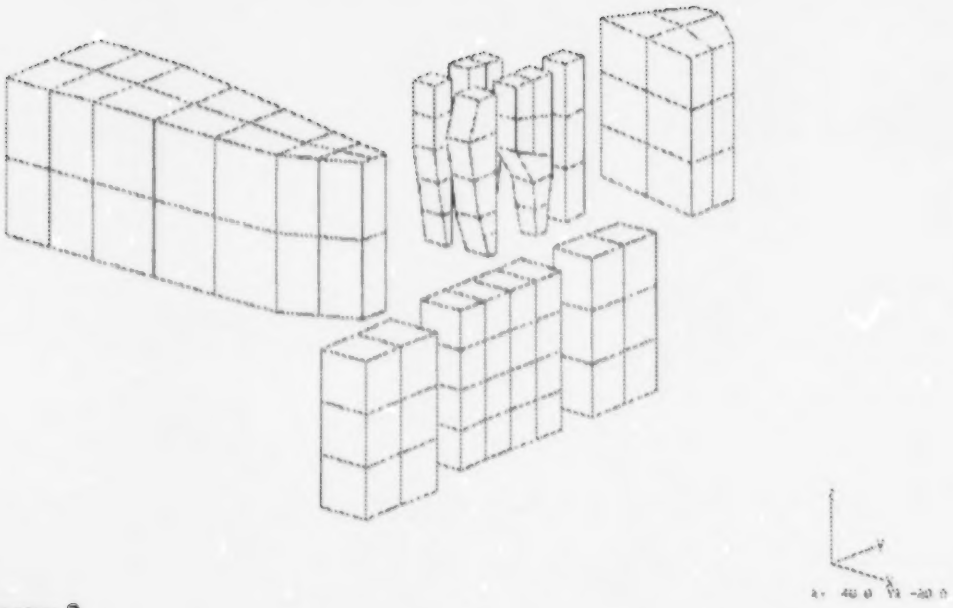


Figure 4. Geometry 2.

Step	Description	Stopes and pillars
1	Central part Upper level	203-09, 211-09, 201-09, L03-09, L11-09, T-03-09, T11-11, T-01-11, 211-11, 201-11, L11-11, T-11-13, T-01-13
2	Central part Lower level	203-11, 201-11
3	Adjacent stopes North	214-09,204-11, 204-09 208-11
4	Adjacent stopes South	202-08, 202-10, 206-10, 202-12, 206-B-12, 206-12, 206-14, 202-14, 202-08

SIMULATIONS

Four different simulations were done using the BEAP3D three-dimensional boundary element software package. The software was run on a SUN 4/270 minicomputer under the Unix operating system, with 32 megabytes of RAM and a 900-megabyte hard disk.

Model	Central part	Surface	Loading	Number of elements	temps CPU (h)
1	simplified	no	1	163	2.52
2	simplified	yes	1	308	6.13
3	simplified	yes	2	308	6.13
4	detailed	no	1	303	unavail.

Table 2. Simulations performed

By combining the two geometries, the presence or absence of the ground surface and the two initial loading conditions, four different models were created. Table 2 defines the characteristics of each model.

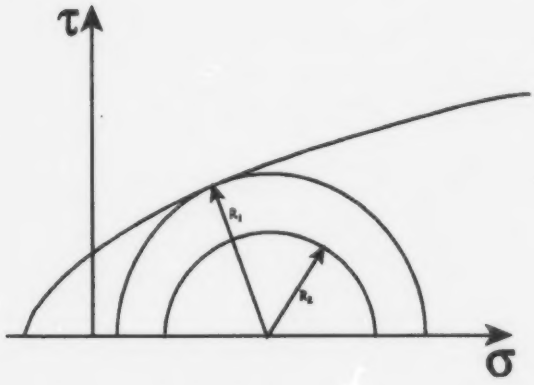
The computing times given in the last column only represent the time needed to create the overall matrix and calculate the solution. The computing times required to obtain the stresses and deformations at interior points are not included.

PRESENTATION OF RESULTS

The graphics post-processor of the BEAP3D software allows us to display isometric or axonometric projections of the stresses around the excavations. It also makes possible the representation of safety factors associated with strength criteria. The figures provided in the Appendix show, for each model in the fourth mining stage, the stresses along the X, Y and Z axes, as well as the magnitude of the principal stresses. In orther to make detailed study of the solutions, transparencies were created, as well as short animated sequences for observing each model in a succession of different orientations.

The stresses were calculated in a box-shaped area, centred on the shaft zone, measuring 100 m by 100 m horizontally and 200 m vertically. The roof of this zone

is 100 m below the surface. The stresses are then represented in two vertical planes, one oriented east-west and the other north-south. These two planes intersect at the centre of the shaft. The use of this geometry for presenting the results provides a precise image of the variation in stresses caused by mining the stopes in the shaft zone.



We have also drawn contours on these planes showing the safety factors associated with a Coulomb criterion corresponding to a cohesion of 4.5 MPa and an angle of friction of 36°, which should correspond to the lower limit of the mechanical strength characteristics of the (undisturbed) rock mass surrounding the Niobec Mine. These values were taken from the report by Labrie et al (1989).

Figure 5. Computation of safety factors

The safety factors were calculated by representing the stresses in terms of their components in the Mohr space (Figure 5). The stresses applied to any face can be determined by constructing the corresponding Mohr circle. It intersects the axis of the stresses normal to the values for the major and minor principal stresses. If this circle intersects the curve representing the criterion, the conditions of stress will cause rupture. On the basis of this geometric representation, we can define the safety factor as the ratio of the radii of the real Mohr circle to those of the circle which would cause rupture (tangent to the straight line representing the Coulomb criterion).

In addition, to characterize the actual influence of mining operations, we have shown the difference in the safety factor before and after excavation of the stopes. A stabilizing influence is defined by values higher than 0, while values less than 0 indicate a destabilizing effect. The figures representing these analyses are also provided in the Appendix.

DISCUSSION OF RESULTS

A detailed examination of the figures described in the preceding paragraph shows the following:

1. The influence of modelling the surface is very slight, thus causing little variation in stresses identified in the shaft zone.

2. The influence of the stopes adjacent to the central part is signifiant in the shaft zone, particularly for the stopes in the southern part of the model because of their large size. The results of the simulations after the fourth mining stage have therefore been given in this report.

3. The mining of large stopes in the central part seems to have a stabilizing influence on the shaft zone by creating the effect of a barrier to the major principal oriented east-west stresses.

4. The concentration of horizontal stress caused by the presence of the horizontal pillar between the upper and lower levels is completely attenuated in the shaft zone.

5. Large dimension stope walls oriented north-south cause significant zones of tension which could result in unstable conditions if such stopes were in fact created.

CONCLUSIONS

The effect of mining ore located close to the production shaft pillar in the Niobec Mine in Quebec was examined using numerical simulation. As a three-dimensional model was necessary, the BEAP3D software package was used. Since the data do not allow construction of a detailed model, and because of constraints related to budget, timetable and practical considerations, an approximate model was prepared by idealizing and simplifying the geometry of the excavations. Because the real size of the stopes was overestimated, the results obtained with this approach should constitute the upper limits (in absolute terms) of the real values.

However, the results show that the excavation of the stopes and pillars in lens 211 should have a stabilizing influence on the shaft zone. The effect of stress concentration in the horizontal pillar in this zone is minimal.

Nevertheless, the results show that zones of high tensile stresses, which could give rise to unstable conditions, are predictable in the walls of the north-south stopes. The seriousness of these condition, however, cannot be determined at present because of the geometric simplicity of the model used to evaluate these zones.

RECOMMENDATIONS

In our opinion, the accuracy of the results obtained, with simulations based on simplified geometry and with the two initial stress models considered, is sufficient to make a decision, in view of the effect on the shaft zone, on continuing to mine the pillars in the central zone. However, the same does not apply to the stability of the stopes themselves. It would therefore be preferable to carry out a more detailed study of the geometry of the stopes and to construct an adequate model. In addition, the low level of precision caused by the variation in initial stresses with depth could be improved, either by a completely new measurement program, or a more detailed, methodical comparison of the measurements made by the instruments still in place in the rock mass and the numerical modelling of mining events.

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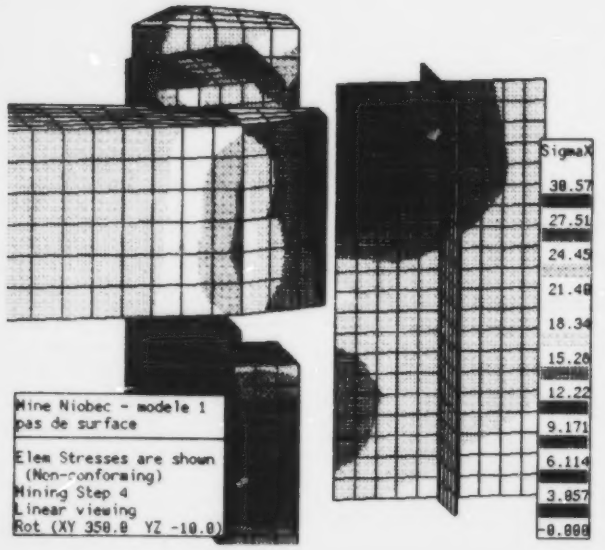
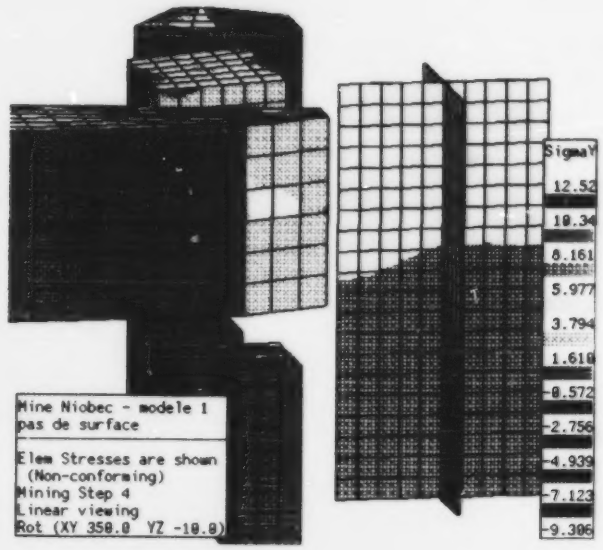
APPENDIX

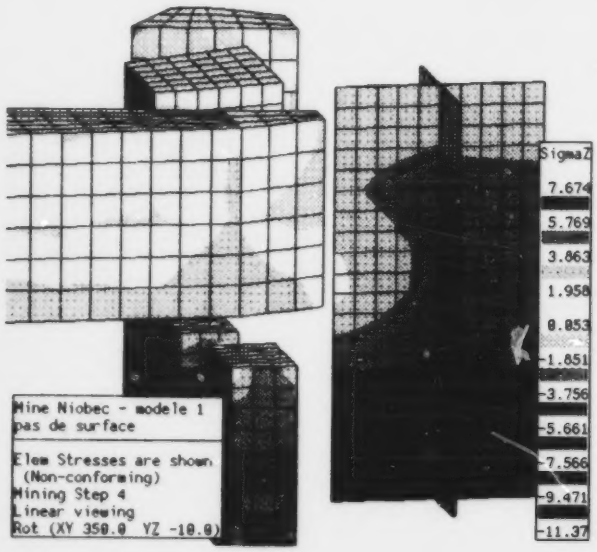
Stress Contours and Safety Factors

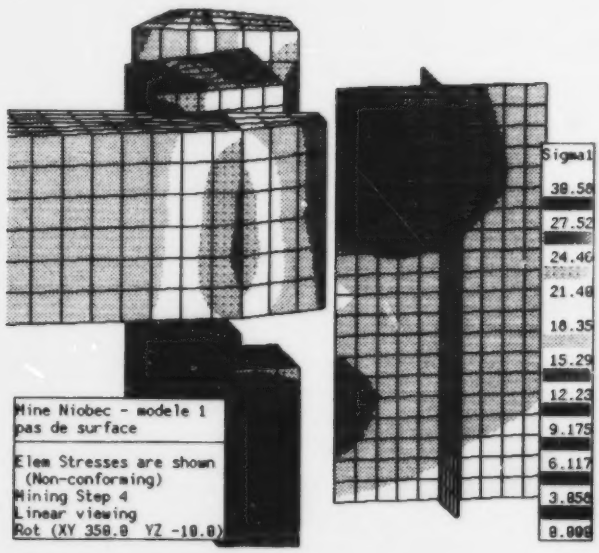
Note:

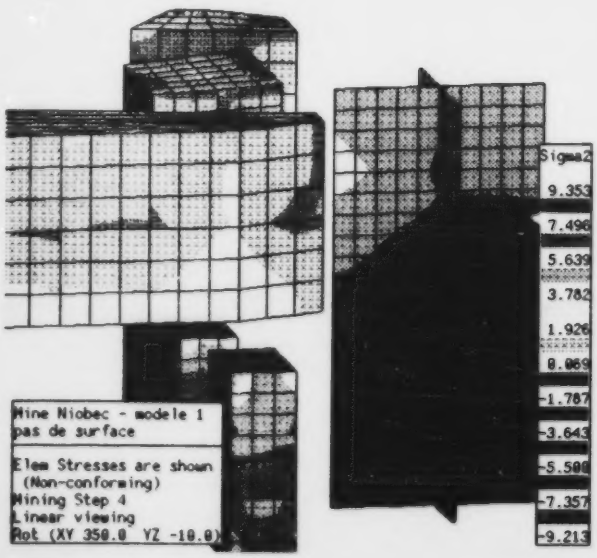
SigmaX	=	east-west normal stress
SigmaY	=	north-south normal stress
SigmaZ	=	vertical normal stress
Sigma1	=	major principal stress
Sigma2	=	intermediate principal stress
Sigma3	=	minor principal stress
User1	=	safety factor (see page 9)
Err/U2	=	difference in safety factors before and after mining

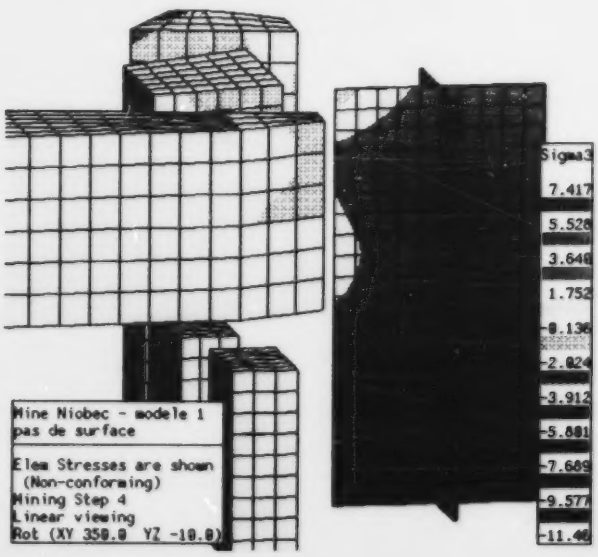

SigmaX
30.57
27.51
24.45
21.40
18.34
15.28
12.22
9.171
6.114
3.057
-0.000
Mine Niobec - modele 1
pas de surface
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)

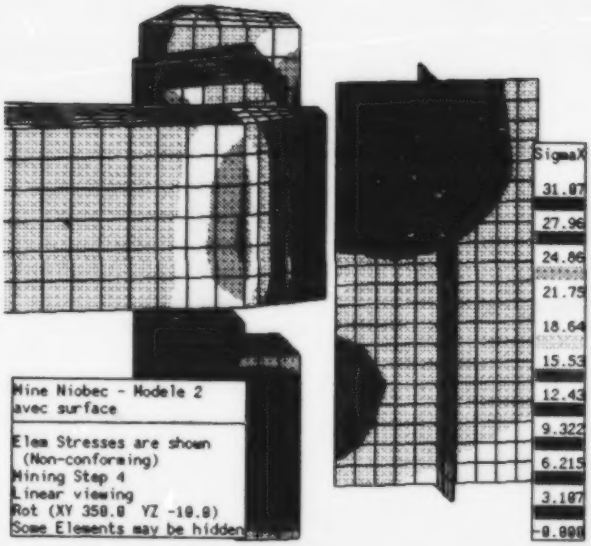

SigmaY
12.52
10.34
8.161
5.977
3.794
1.610
-0.572
-2.756
-4.939
-7.123
-9.306
Mine Niobec - modele 1
pas de surface
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)

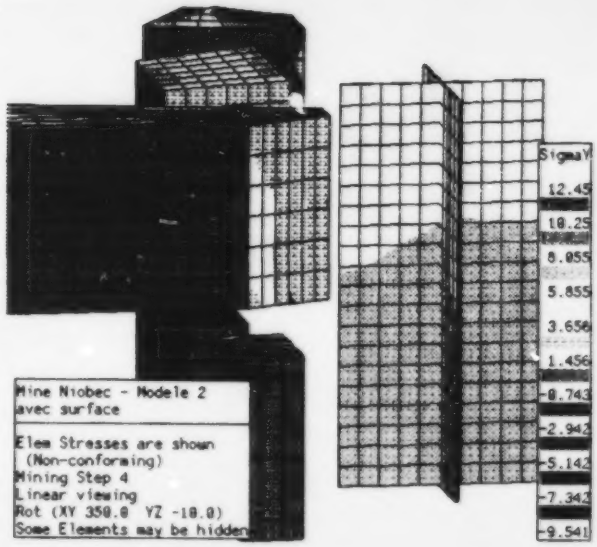

SigmaZ
7.674
5.769
3.863
1.958
0.053
-1.851
-3.756
-5.661
-7.566
-9.471
-11.37
Mine Niobec - modele 1
pas de surface
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)

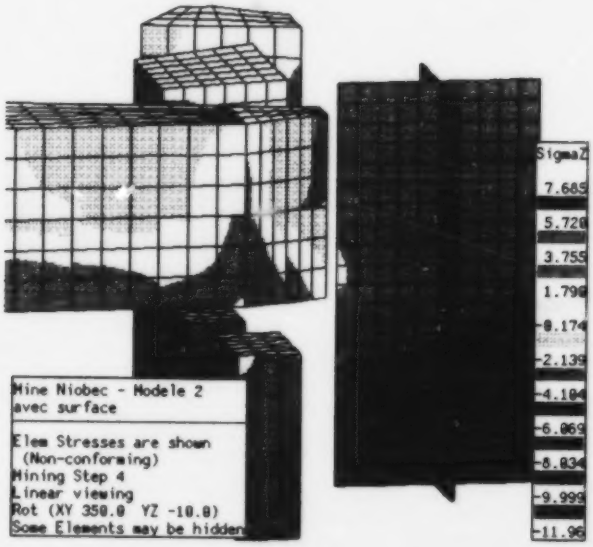

Sigma1
30.58
27.52
24.46
21.40
18.35
15.29
12.23
9.175
6.117
3.058
0.000
Mine Niobec - modele 1
pas de surface
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)

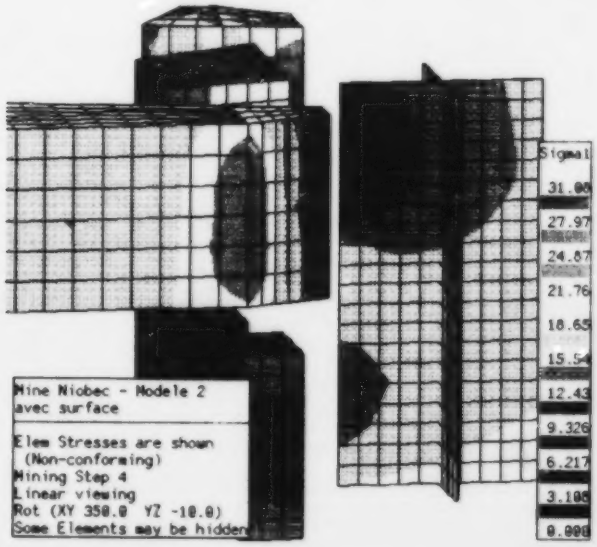

Sigma2
9.353
7.490
5.639
3.782
1.926
0.069
-1.787
-3.643
-5.500
-7.357
-9.213
Mine Niobec - modele 1
pas de surface
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)

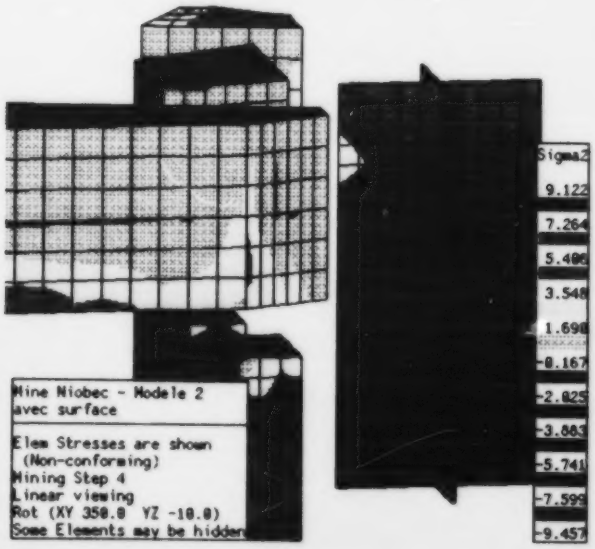

Sigma3
7.417
5.526
3.640
1.752
-0.136
-2.024
-3.912
-5.801
-7.689
-9.577
-11.46
Mine Niobec - modele 1
pas de surface
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)

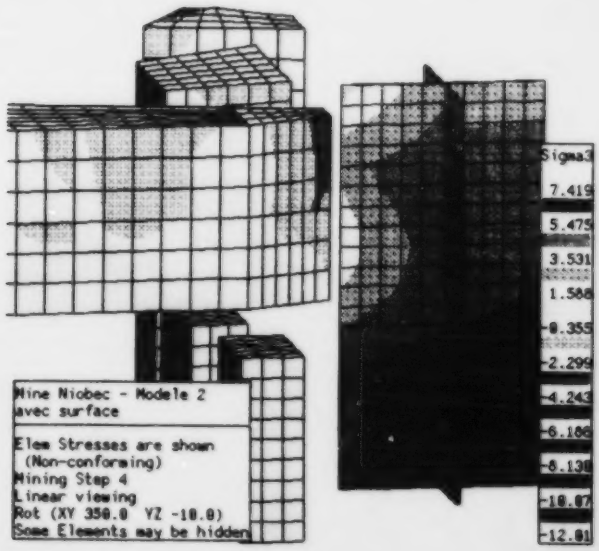

SigmaX
31.07
27.96
24.86
21.75
18.64
15.53
12.43
9.322
6.215
3.107
-0.000
Mine Niobec - Modele 2
avec surface
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)
Some Elements may be hidden

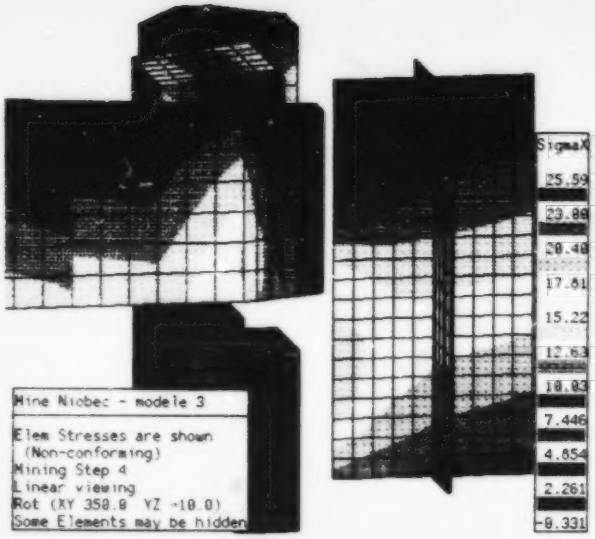

SigmaY
12.45
10.25
8.055
5.855
3.656
1.456
-0.743
-2.942
-5.142
-7.342
-9.541
Mine Niobec - Modele 2
avec surface
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)
Some Elements may be hidden

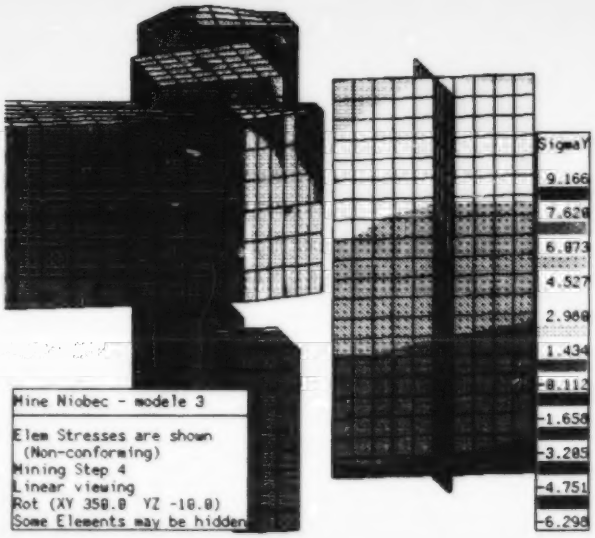

SigmaZ
7.685
5.720
3.755
1.790
-0.174
-2.139
-4.104
-6.069
-8.034
-9.999
-11.96
Mine Niobec - Modele 2
avec surface
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)
Some Elements may be hidden

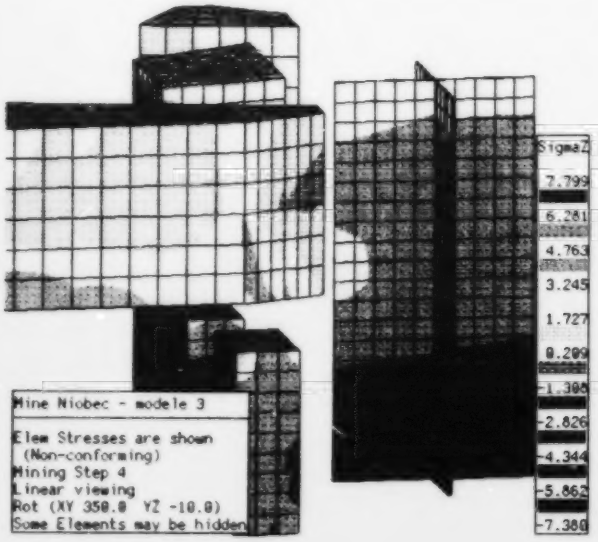

Sigma1
31.00
27.97
24.87
21.76
18.65
15.54
12.43
9.326
6.217
3.108
0.000
Mine Niobec - Modele 2
avec surface
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)
Some Elements may be hidden

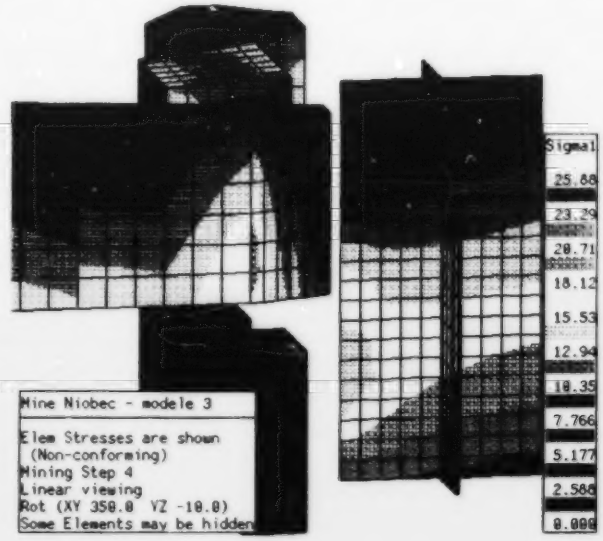

Sigma2
9.122
7.264
5.406
3.548
1.690
-0.167
-2.025
-3.883
-5.741
-7.599
-9.457
Mine Niobec - Modele 2
avec surface
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)
Some Elements may be hidden

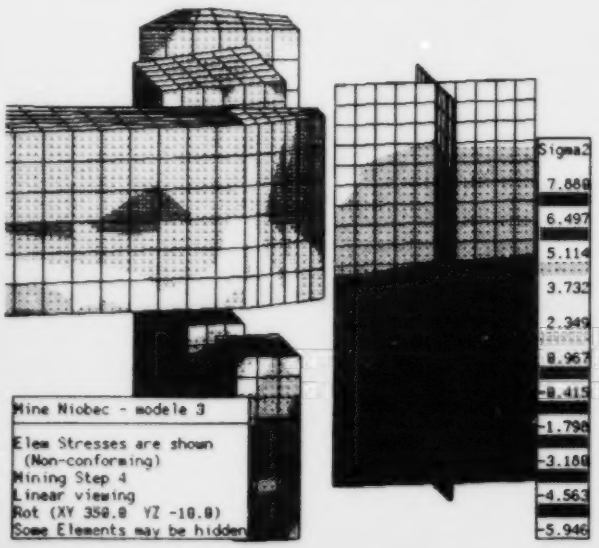

Sigma3
7.419
5.479
3.531
1.588
-0.355
-2.299
-4.243
-6.186
-8.130
-10.07
-12.01
Mine Niobec - Modele 2
avec surface
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)
Some Elements may be hidden

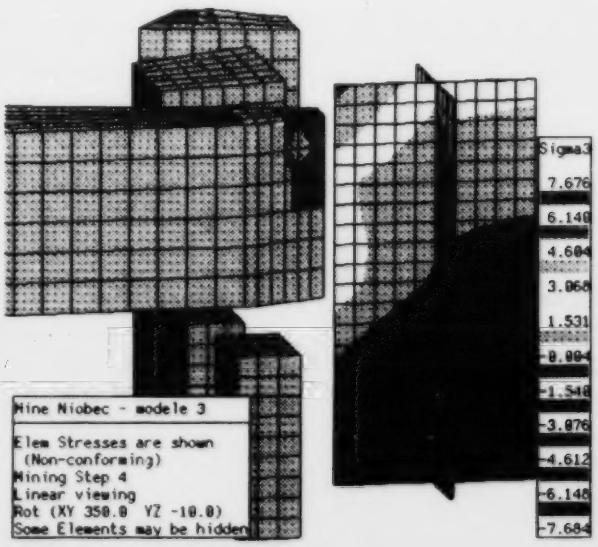

SigmaX
25.59
23.08
20.48
17.81
15.22
12.63
10.03
7.446
4.854
2.261
-0.331
Mine Niobec - modele 3
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)
Some Elements may be hidden

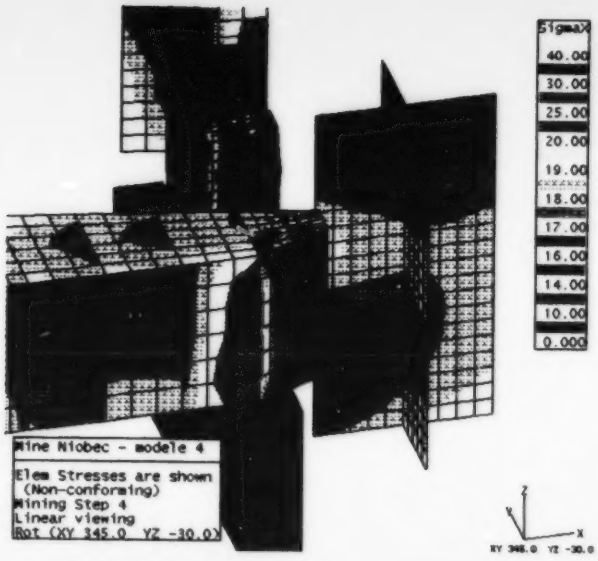

SigmaY
9.166
7.620
6.073
4.527
2.980
1.434
-0.112
-1.658
-3.205
-4.751
-6.298
Mine Niobec - modele 3
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)
Some Elements may be hidden

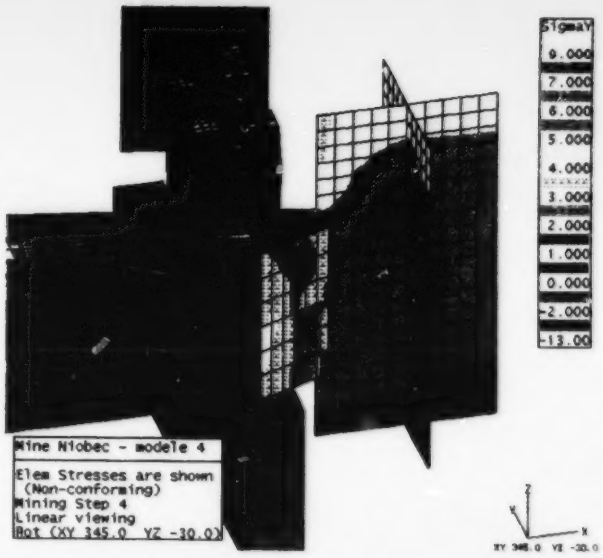

SigmaZ
7.799
6.281
4.763
3.245
1.727
0.209
-1.308
-2.826
-4.344
-5.862
-7.380
Mine Niobec - modele 3
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)
Some Elements may be hidden

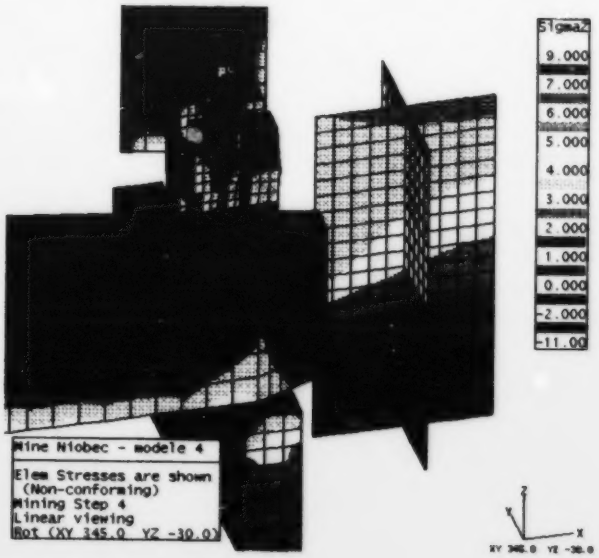

Sigma1
25.88
23.29
20.71
18.12
15.53
12.94
10.35
7.766
5.177
2.588
0.000
Mine Niobec - modele 3
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)
Some Elements may be hidden

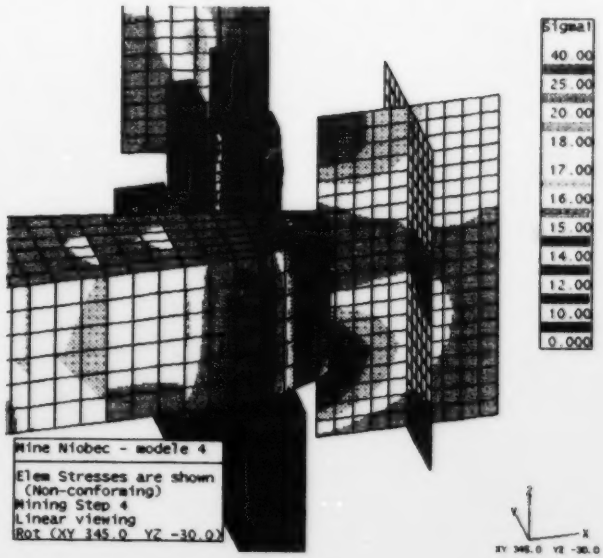

Sigma2
7.880
6.497
5.114
3.732
2.349
0.967
-0.415
-1.798
-3.180
-4.563
-5.946
Mine Niobec - modele 3
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)
Some Elements may be hidden

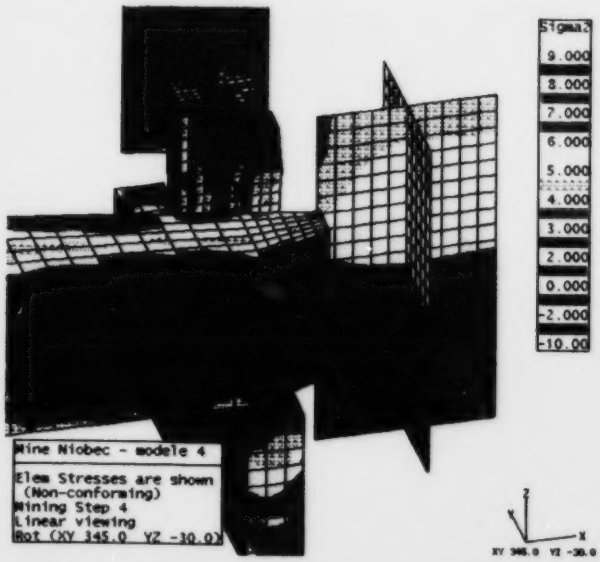

Sigma3
7.676
6.140
4.604
3.068
1.531
-0.004
-1.540
-3.076
-4.612
-6.148
-7.684
Mine Niobec - modele 3
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 350.0 YZ -10.0)
Some Elements may be hidden

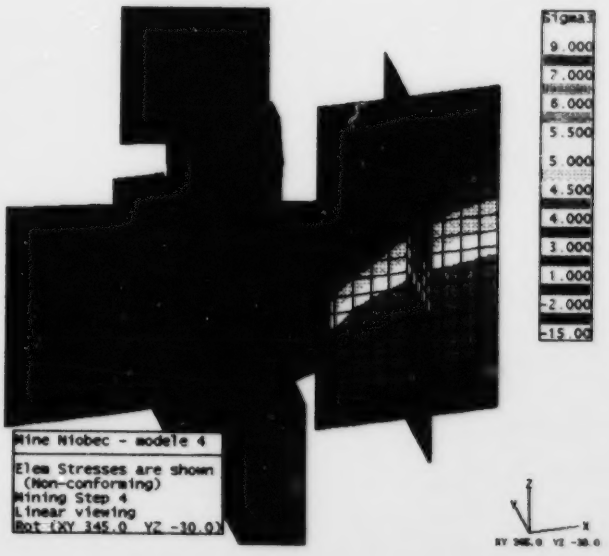

SigmaX
40.00
30.00
25.00
20.00
19.00
18.00
17.00
16.00
14.00
10.00
0.000
Mine Niobec - modele 4
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 345.0 YZ -30.0)

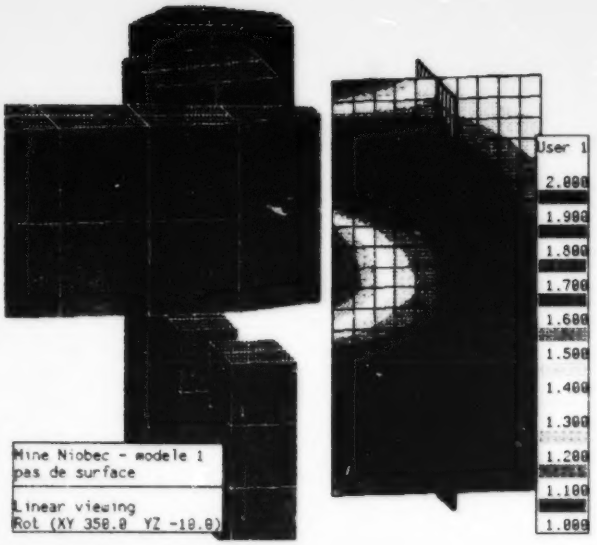

SigmaY
9.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
-2.000
-13.00
Mine Niobec - modele 4
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 345.0 YZ -30.0)

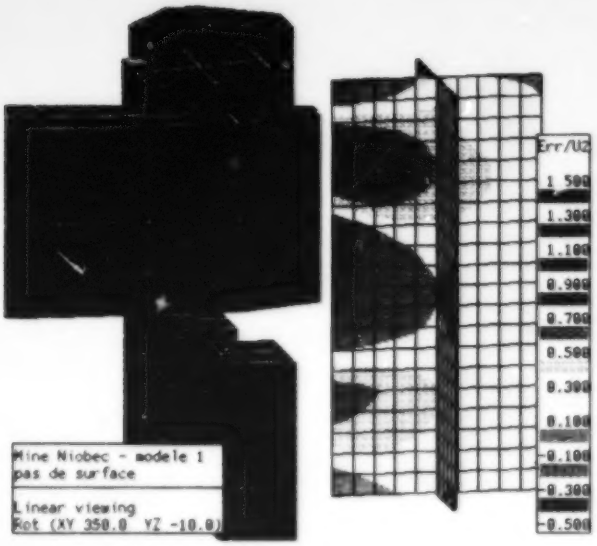

Sigma2
9.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
-2.000
-11.00
Mine Niobec - modele 4
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 345.0 YZ -30.0)

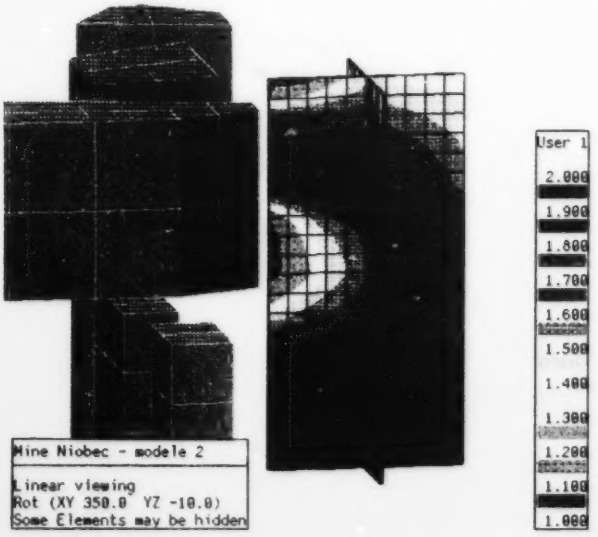

Sigma1
40.00
25.00
20.00
18.00
17.00
16.00
15.00
14.00
12.00
10.00
0.000
Mine Niobec - modele 4
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 345.0 YZ -30.0)

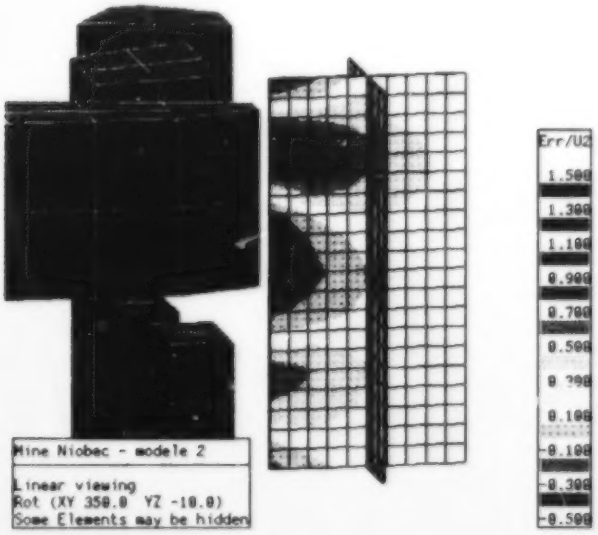

Sigma2
9.000
8.000
7.000
6.000
5.000
4.000
3.000
2.000
0.000
-2.000
-10.00
Mine Niobec - modele 4
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 345.0 YZ -30.0)

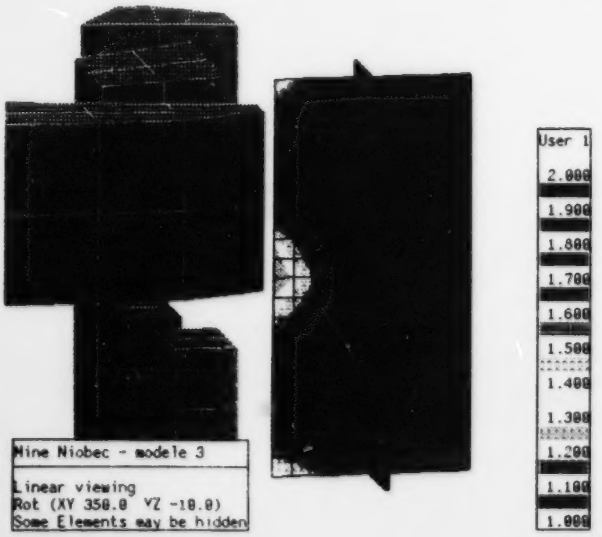

Sigma3
9.000
7.000
6.000
5.500
5.000
4.500
4.000
3.000
1.000
-2.000
-15.00
Mine Niobec - modele 4
Elem Stresses are shown
(Non-conforming)
Mining Step 4
Linear viewing
Rot (XY 345.0 YZ -30.0)

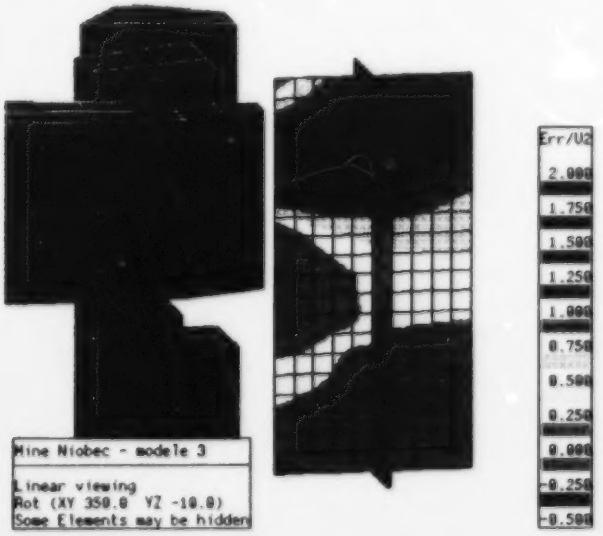

User 1
2.000
1.900
1.800
1.700
1.600
1.500
1.400
1.300
1.200
1.100
1.000
Mine Niobec - modele 1
pas de surface
Linear viewing
Rot (XY 350.0 YZ -10.0)

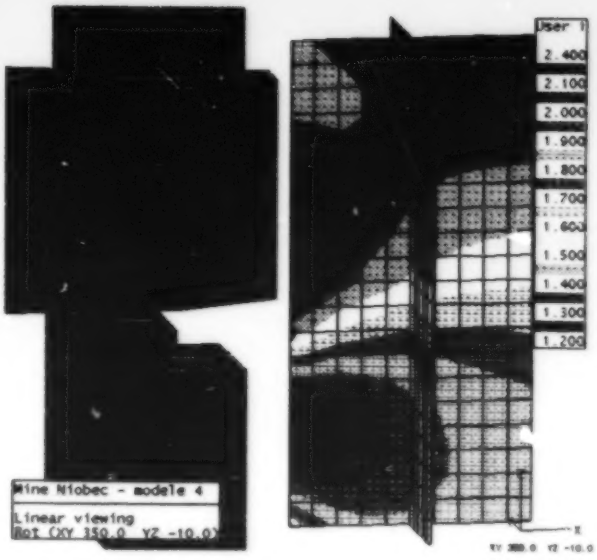

Err/U2
1.500
1.300
1.100
0.900
0.700
0.500
0.300
0.100
-0.100
-0.300
-0.500
Mine Niobec - modele 1
pas de surface
Linear viewing
Rot (XY 350.0 YZ -10.0)

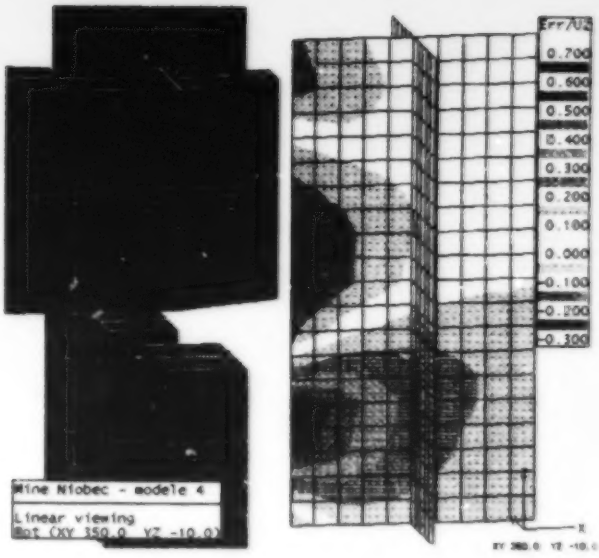

User 1
2.000
1.900
1.800
1.700
1.600
1.500
1.400
1.300
1.200
1.100
1.000
Mine Niobec - modele 2
Linear viewing
Rot (XY 350.0 YZ -10.0)
Some Elements may be hidden


Err/U2
1.500
1.300
1.100
0.900
0.700
0.500
0.300
0.100
-0.100
-0.300
-0.500
Mine Niobec - modele 2
Linear viewing
Rot (XY 350.0 YZ -10.0)
Some Elements may be hidden


User 1
2.000
1.900
1.800
1.700
1.600
1.500
1.400
1.300
1.200
1.100
1.000
Mine Niobec - modele 3
Linear viewing
Rot (XY 350.0 YZ -10.0)
Some Elements may be hidden


Err/U2
2.000
1.750
1.500
1.250
1.000
0.750
0.500
0.250
0.000
-0.250
-0.500
Mine Niobec - modele 3
Linear viewing
Rot (XY 350.0 YZ -10.0)
Some Elements may be hidden


User 1
2.400
2.100
2.000
1.900
1.800
1.700
1.600
1.500
1.400
1.300
1.200
Mine Niobec - modele 4
Linear viewing
Rot (XY 350.0 YZ -10.0)


Err/UZ
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
-0.100
-0.200
-0.300
Mine Niobec - modele 4
Linear viewing